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TRANSACTIONS.

A NEW THEORY OF THE SURFACE MARKINGS OF THE MOON.

By E. MILLER, Lawrence, Kan. Read before the Academy January 3, 1896.

Our next-door neighbor, the Moon, although so near, has its mysteries. The problems arising from the lunar theories are so many and of such complex nature that as yet no complete solution of them has been reached. The dominant features are the craters; and it is practically true that all lunar theories begin with them. The mountain ranges, the craters, the cracks and the seams upon the Moon, are clearly and distinctly defined with the assistance of a good telescope; and by means of the art of the photographer, there are to-day better maps of the lunar surface that is exposed to our view than any maps ever constructed of a corresponding portion of the Earth's surface.

Three theories have attracted considerable attention, to which a large amount of industry, patience and enthusiasm has been given. If not considered presumptuous, I shall add another theory, one that is entirely new and original, so far as is known. A brief outline of the first, second and third will be given before touching upon the fourth. The first is known as the "volcanic theory," the second as the "meteoric," and the third as the "tidal theory."

All known active and extinct terrestrial craters are volcanic beyond a doubt, and the great mass of writers affirm the same to be true of the lunar craters, all of which that are exposed to our view being, however, of the extinct variety. No craters upon our globe begin to approximate in size the largest of the Moon. There are lunar craters 800 miles in diameter, and they range from that size down until they become imperceptible. Those large plains upon our lunar surface, heretofore called seas, and of oval outline, are now by some classed as craters. The largest known crater upon Earth does not exceed 17 miles in diameter. Volcanic action upon our neighbor, the Moon, must have been in its day much more terrific than anything of a similar nature upon our own planet. The number of lunar craters visible to us is somewhere in the neighborhood of 30,000. Estimating one-half the Moon's surface at about 7,000,000 square miles, and the surface of North America, excluding Greenland and the West India islands, at 8,000,000, we shall find by the most reliable statistics that North America has only one-tenth as many craters, both active and extinct, as one-half the Moon's total surface. This apparent discrepancy may be accounted for when it is considered that upon the Earth two powerful agencies — aqueous and atmospheric — have been at work for perhaps millions of years, producing a demolition of craters, or burying them under successive layers of geologic debris. Without discussing the "volcanic theory" in detail, this simple reference to it must be considered sufficient.

Mr. G. K. Gilbert delivered a very able and interesting address December 10, 1892, before the Philosophical Society of Washington, on "The Moon's Face," of which the following may be considered the main thought: Basing his discussion upon the supposition that when the Moon was in the form of a ring similar to the rings of Saturn the time came when the stability of the lunar ring was destroyed and an indefinite number of moonlets, constituting in fact, a meteoric swarm, resulted. Under the superior attraction of one or more of the largest masses, a trend toward that one was set up, and the impacts or collisions thus produced not only fused the striking meteorite but also that portion of the nucleus that was struck. A coalescence took place, the central body grew in size, and its power of attraction increased accordingly. In harmony with the laws of celestial dynamics, the velocity of the moonlets toward the central controlling mass would increase, and the energy expended would be sufficient to melt every moonlet, even though it should be composed of the most refractory substance. The portion of the surface of the central mass struck by the moonlet would itself be fused, and there would be formed a cup-shaped depression similar to the crater forms now seen upon the Moon, together with their attending phenomena. The larger the moonlet, the larger and deeper would be the depression and the greater the fusion of the rock material. The smaller the moonlet, the shallower would be the crater's depth, and less its diameter. I have seen in the cuts and gullies made by the overflow, and backwater, and subsequent subsidence, of the San Pedro river in southern Arizona, the plastic mud deposited by the falling waters of such consistency, that when a pound or two-pound rock was dropped into that mud, an examination of it next day showed a crater-like form resembling exactly the forms of the lunar craters, taking the normal type as an example.

" If a drop of water be made to fall on a still surface of water, the outward-moving annular wave at one instant incloses a crater ; at the next instant a mound rises in the center of the crater." In the case of the viscous mud, as shown in the example of the San Pedro, if a stone fall from a certain height, " a cup-like cavity or crater with a smooth rim will be produced ; if it fall from a greater height it will produce a larger cup with smooth rim and smooth dome-like hill in the center." An experiment of this sort can easily be performed. The white streaks, constituting one of the great lunar features, is by this theory of impact also accounted for. According to Dr. B. A. Gould, " The most remarkable appearance of the Moon, for which nothing on Earth furnishes an example, is presented by those immense radiations from a few of the larger craters — perfectly straight lines, as though marked with chalk along a ruler — starting from the center of the crater and extending to great distances over every obstruction. My explanation is, that a meteorite, striking the Moon with great force, spattered some whitish matter in various directions. Since gravitation is much feebler on the Moon than with us and atmospheric obstruction of consequence does not exist, the great distance to which the matter flew is easily accounted for." Accepting the premises on which the " meteorite theory " is based as true, all the characteristics of the Moon's surface — craters, streaks, central domes, rising from the floors of the craters, and even the building of the Moon itself — can be explained on the theory of the impact of moonlets or meteorites upon the central mass.

But it may be stated that the impact of the larger masses upon the central one, in order to produce results such as we see on the Moon's surface, is a theory that contains inherent and radical difficulties. The diameter of the Moon is about 2,100 miles, and by this theory we have a moonlet whose impact was capable of producing a crater 800 miles in diameter. We may reasonably suppose that when the lunar ring was broken into fragments, the central mass may not have had a diameter of over 1,000 miles and collisions would take place not long after the dismemberment. A collision between two bodies, one 1,000 miles in diameter and the other 800 miles in diameter, would break both bodies into a multitude of smaller bodies, and hurl them outward into space in a thousand different directions. This process would be carried on just as fast as the meteoric masses of the old ring should be drawn towards the center. A swarm of asteroids would therefore, under such conditions, have taken the place now occupied by the Moon. Yet it is fair to assume that the "meteoric theory" is true as one of the factors in any lunar theory that may be advanced. The volcanic is also another factor that must be considered as equally important. There is, therefore, no objection to the statement that both forms of action, the volcanic and the impact of meteors, may have had each its due share in bringing about the present condition of the Moon's surface.

The third or "tidal theory" supposes a time when the Moon was liquid but covered with a thin crust. "The Moon then rotated more rapidly than now, and great tides, excited by the Earth's attraction, rocked and cracked its crust, and here and there squeezed out a portion of the liquid nucleus, which flowed back again when the tidal wave had passed; but congelation caught the flood at its edges, so as to mark its limit by a solid ridge. By each successive tide the operation was repeated, with the result that the wall was given a circular form and was gradually built up. The process was finally closed by the congelation of lava in the orifice, and while the congelation was in progress the last feeble eruption sometimes produced a central hill." The tidal theory is quite strong in certain directions, while in others it is weak.

I now desire to pass by these three forms or theories, and construct another which may or may not have merit of its own; a system of lunar dynamics, which, so far as I know, has never been looked at in the light in which I now propose to consider it. The suggestion is pertinent right here, that this fourth theory does not leave out of sight the other three as factors of importance in the solution of the problem in hand.

After the Moon had collected her material together into the form of a globular mass, and before becoming a rigid body as it is now known to be, that is when still a gaseous or liquid body, there is scarcely a doubt as to the existence of a force within the Moon powerful enough to produce each and all the peculiar markings on the lunar surface. The most important member of the solar system, the Sun, is in either a gaseous or liquid state, and has been so for millions of years, and will continue to be so for millions of years more. During all these years the sun has been, and will continue to be, diminishing in size at the rate of about 250 feet in diameter per year. The annual contraction of the Sun's mass will in time not only solidify the Sun, but diminish very rapidly toward the end the amount of heat given off. Finally, the condition of the Sun may become that of a cold, dark body, destitute of both heat and light, and if there be no atmosphere and aqueous vapor such as we are acquainted with, then the solar surface will present an appearance similar to that of the Moon—a surface covered with mountain ranges and peaks, craters, fissures, and streaks. But if an atmosphere and aqueous vapor should be in existence at that remote time of the future, then surface markings resembling those of the earth will characterize the surface of the Sun.

The contraction of the Sun at the rate of 250 feet per annum is sufficient, according to the theory of celestial dynamics, to produce all the heat the sun now gives off, and moreover is enough for that purpose until the Sun is diminished to the size of a body sensibly smaller than now. This contraction of the Sun and the consequent radiation of heat may in part be the form of energy, or one of the forms of energy, in operation upon and within the Sun, to which the sun-spots owe their origin. Sun-spots range in diameter from 500 to 100,000 miles or even more, and the penumbra is still greater. As to their depth, they seldom exceed 2,500 miles, although in one instance, observed by Mr. Langley, the enormous depth of 5,000 miles was probably reached.

The force, or forces, at work upon and within the Sun will, after the lapse of ages, leave the body of the Sun in a viscous condition, and spots formed under such circumstance will become permanently fixed in the form of craters possessing the essential characteristics of the lunar craters. Not only the forms that are typical or normal, but those that are broken and misshapen, with rims, in some cases elevated several thousands of feet above the surrounding surface, but slightly pushed up in others; with cavities reaching in some instances to immense depths; and with fissures and streaks, in straight or irregular lines, will all be found to dot the solar surface as abundantly as do those upon the face of the Moon. If there should be neither atmosphere nor moisture, then and there, all the rugged forms and appearances, the precise counterparts of those upon the Moon, will mark the period when the Sun will have ceased to radiate heat and light throughout the solar system, and will have become a dark, dead body, ready for some great catastrophe by which it may be transformed into another and perhaps more beautiful system.

Taking the Sun as an example of a mode of action, is it beyond the realm of truth and of science to formulate a theory for the Moon similar to that which is now at work, and is actually passing before our eyes, upon the Sun ? The nebular hypothesis gives us a starting-point—a lunar ring, at first complete it may be, then broken into a multitude of fragments. Gravitation molded these fragments into a veritable planet that was to be our nearest neighbor. In its earliest stages, the Moon was not a solid, rigid body, but a mass of gaseous or liquid matter in a condition of white heat. In time it contracted its volume; heat was evolved; and intense action set up in the mass. The results would be noticeable upon the surface; and manifestations of protuberances and other phenomena, similar to those of the Sun, would naturally follow. As the ages rolled by, the heat would disappear in part by radiation, and partly by absorption, to be stored away as latent heat. As there was no atmosphere nor moisture, the resulting form of the Moon's surface then would constitute a photograph of its condition true to life as long as the solar system should endure.

In conclusion, therefore, is not the assumption that the Moon-spot theory, to coin a term, is in sufficient harmony with well-established mathematical and dynamic principles to constitute a theory of as great importance as any other, and perhaps more satisfactory in that it meets the conditions of astronomical science at all points ?

This fourth theory does not claim to discard entirely the volcanic agencies, or the impact of meteors, or tidal action, but it does claim to be more general in its operations, more wide-reaching, and yet allowing to a certain extent the agencies of other forces as restricted and collateral, within limits.

The contraction of the Sun's mass, the development of heat, and the immense energy consequent upon that development, as seen in splendid outbursts of the protuberances, the formation of sun-spots which, crossing the Sun's disc, present such wonderful changes in form, size, and movement, may not all this be but a transcript of the story that the Moon might tell concerning the events that took place upon and within the lunar mass millions of years ago ? May not the present condition of the Moon's surface be a prophecy of what the Sun's will be in the far-distant future ?

The energy of lunar heat when the Moon was an incandescent body must have manifested itself in results similar to those which the energy of solar heat now produces. The one is but a type of the other.